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ABSTRACT

Papert (1980) contended that the value of the Logo computer program lies in its ability to allow children to take control of their own learning processes and to acquire skills and concepts independently of a stifling curriculum generated by adults. It is argued here that Papert's ideas are preserved when teachers' modelling of cognitive strategies helps mediate children's internalization of abstract concepts and provides them with the knowledge of strategies necessary for independently thinking through Logo problem solving tasks. This paper examines how the recorded discourse structure of some Logo lessons illustrates a teacher's use of mediated strategies to facilitate the shift in children's development from regulation by others to self-regulation of cognitive processes. A discourse analysis of Logo lessons given to two pairs of 5-year-old children revealed that elicitations of both teacher and child decreased over time as the children gained greater mastery; teacher directives decreased as peer collaboration increased; responses of children to metacognitive prompts remained stable; and children's talk became increasingly task-oriented. It is concluded that for children to learn Logo successfully, careful structuring of the teaching process may be required. (Author/RH)

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Talking to the turtle: A discourse analysis of Logo instruction

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Abstract

The effect of Logo on children's cognitive development may depend upon the nature of the instructional process. From a Vygotskian perspective, the teacher's use of mediated strategies is conceptualized as the most critical component. The transition from other-regulation to self-regulation should be reflected in the discourse structure as children acquire greater competence in programming through adult scaffolding of commands. A discourse analysis of Logo lessons given to two pairs of five year old children revealed that both teacher and child elicitations decreased over time as the children gained greater mastery; teacher directives decreased as peer collaboration increased; children's responses to metacognitive prompts remained stable; and, children's talk became more task oriented. These findings suggest that successful learning of Logo may involve a careful structuring of the teaching process.

Previous studies on the effects of Logo instruction have been concentrated on whether it facilitated children's cognitive development in the areas of comprehension monitoring, planning skills, or cognitive reflectivity (Clements, 1985; Clements & Gullo, 1984; Miller & Emihovich, in press; Pea & Kurland, 1984). To date, the evidence is mixed as to whether these attempts have been successful; where positive outcomes have been achieved, several researchers have suggested that it is not Logo instruction per se which is important, but the methods used to teach it (Kull, 1986; Leron, 1985; Miller & Emihovich, in press). More specifically, the teacher's use of mediated strategies is conceptualized as the most critical aspect of Logo instruction (Declos, Littlefield, & Bransford, 1985; Emihovich & Miller, 1986).

Emphasizing the quality of teacher talk entails a shift away from examining the outcomes of Logo learning, and instead focusing on the process by which learning is achieved. The effects of spoken language in the classroom on children's learning is a well researched topic, one utilizing two quite different analytic approaches (see Cazden, 1985 for an extensive review of this area). In the process-product approach, the observer comes into the classroom armed with a set of predetermined categories, and records the frequency of behavior within each category. These behaviors are then studied in relation to outcomes such as achievement on various standardized tests. In the second approach, loosely labeled as the "sociolinguistic" approach, the observer constructs categories on the basis of meaningfulness from the participants' point of view, and from the observer's qualitative analyses of classroom talk through audio or videotaped records. The latter approach is followed in this paper, with an emphasis on the relationship between language and cognition in one specific context, learning Logo. The theoretical framework is drawn from research on sociolinguistic studies of classroom discourse, and cognitive developmental studies from a Vygotskian perspective. Because computers have only recently been introduced into the classroom, relatively little work has been done on the kinds of talk occurring around computers with regard to cognition. Studies have been focused either on the cognitive content of talk produced by individual children in absence of any social interaction (McBride, 1984), or on the nature of social interactive speech without regard to on-going cognitive processes within the children (Hungate & Heller, 1984; Strand, Gilstad, McCollum & Genishi, 1986). The one exception is recent studies of children working with word processing, where both the nature of talk and its cognitive content receive attention (Heap, 1986; Levin, Boruta &

Vasconcellos, 1983; Riel, 1983).

Papert (1980) contended that the value of Logo lies in its ability to allow children to take control of their own learning processes, independent of an adult-generated curriculum which stifles creativity and interest. It will be argued here that while some adult control is needed to structure the learning process, Papert's ideas in spirit are preserved when the teacher's modelling of cognitive strategies helps mediate children's later internalization of abstract concepts. This mediated activity on the teacher's part provides children with the knowledge of strategies necessary for thinking through Logo problem solving tasks on their own. The major issue examined in this paper is how the discourse structure of Logo lessons illustrates the teacher's use of mediated strategies to facilitate the shift from other-regulation to self-regulation of cognitive processes in young children.

Theoretical Framework

Since the theoretical framework underlying this research is considerably more complex than can be fully discussed here, only the more significant concepts will be outlined. The reader is referred elsewhere for a more comprehensive description (Emihovich & Miller, 1985). This preliminary reference model represents an attempt to examine computer learning within an interdisciplinary framework, an approach needed to sort out the complexity of how learning occurs within specific social contexts among different types of learners.

In considering the relationship between language and cognition (or speech and thinking, as Wertsch [1979] pointed out is the more correct interpretation), Vygotsky (1978) noted that the transition from other-regulation to self-regulation of behavior was a function of mediated activity, with the origins of such activity located in the social interaction between the child and adult. Through the adult's speech which guides and directs the child's actions, Wertsch noted that:

> ...the child does not perform the requested behaviors because she/he understands the directive with its associated definition of situation. Rather, the child comes to understand the directive with its associated definition of situation because she/he has performed the behavior. That

> is, the child comes to understand the task situation as a result of behaving (under someone else's guidance) as if she/he understood it and of trying to create a coherent account of the relationship between speech and action. (1979, p. 21)

Another way of considering this idea is to state that the mediated strategies provided by the adult become the "scaffold" by which children cross the "zone of proximal development" (Wertsch, McNamee, Budwig & McLane, 1980; Wood, Bruner & Ross, 1976). Children may perform tasks the nature of which they do not fully understand, and they develop competence through the gradual internalization of strategies acquired through adult-child (or more capable peers) interaction (Cazden, 1981).

Where the computer fits into this framework is that it is a cultural device which amplifies cognitive processes (Olson, 1985). While such machines did not exist in Vygotsky's time, he recognized the importance of tools which facilitate mediated activity. When interactive software is used, however, the computer becomes more than just a tool, but also functions as a "sign" since the programming language used (in this case, Logo) and the subsequent messages on the screen operate as a communicative language in its own right. Persons using the computer are in effect 'talking' to it and receiving information in return. One of the more intriguing aspects of computer discourse with Logo is how often the adult refers to the "turtle" as 'telling' the children what went wrong. This view suggests that in this situation the computer has to be treated as another interactional partner and not just simply as a tool, as would be the case with word processing or instructional software. Taking this perspective does not mitigate the importance of Vygotsky's ideas of the origins of thought as located within adult-child interactions; it does suggest the possibility that the future nexus of cognition and social interaction may need to be broadened to include intra-psychological functioning vis-a-vis an 'intelligent' interactive tutor systems like the computer.

In analyzing the transition from interpsychological to intrapsychological functioning in a problem solving situation, Wertsch (1979) identified four successive levels of interaction, which he carefully noted did not comprise an exhaustive list of precisely defined stages, but rather were suggestive of

possible points in the transition from other-regulation to self-regulation. Wertsch's levels of interaction are applied to an analysis of the discourse structure of Logo lessons carried out as part of an experimental study designed to enhance preschool children's comprehension monitoring skills. In this study, children were taught preliminary Logo programming concepts. As in most natural classroom settings, the teacher exercised considerable control over the discourse structure, since a predetermined lesson format was used to introduce Logo concepts. However, because of individual differences in the children's ability to master certain concepts, and because the talk centered around a machine utilizing an interactive language, the instructional discourse in this setting can be distinguished from classroom discourse of other types. Both the similarities and differences will be used to illustrate how the transition from other-regulation to self-regulation in children's monitoring performance was accomplished.

Analytic Method

Participants

As part of of an experimental study intended to assess whether experience in Logo programming increased young children's metacognitive skills in self-monitoring (Miller & Emihovich, in press), two pairs of randomly selected five year old children working in pairs were given a total of eleven Logo lessons over a three week period, in four, thirty minute sessions per week. Pair 1 consisted of Karen , a Black American girl, and Andy, a Black children of Ethiopian origin. Pair 2 consisted of Mike, an Asian-American boy, and Tina, a Black American girl. The children were enrolled in a university laboratory school which served not only faculty-student parents from the university, but which also drew half the school population from low income families in the community.

Procedure

The children worked in a special room away from the classroom for their lessons, using an Apple II+ microcomputer. The Logo lessons followed the sequence of lessons employed by Clements & Gullo (1984) in which children first learn isolated "turtle" commands, and then learn to write procedures which incorporate the commands using a special support program for young children developed by Clements (1983). All the lessons were videotaped; to illustrate changes in behavior using the

constant comparative method (Glaser & Strauss, 1967), data are reported from transcriptions made of the second lesson in week 1 and the ninth lesson in week 3 for each pair.

The videotapes were analyzed with reference to three types of coding systems: linguistic categories used by Sinclair & Coulthard (1975) and Mehan (1979), and researcher-generated categories designed to promote metacognitive thinking. Sinclair & Coulthard's (1975) model was selected because to a large extent the Logo lessons were tightly structured along the lines of traditional classroom discourse. However, this model could not account for actions which were contextually negotiated, particularly the teacher's shift from knowledge-giver to knowledge-facilitator. For this reason, Mehan's (1979) work on the evaluation of initiated actions and researcher-generated categories of metacognitive teaching acts were more appropriate. The cognitive teaching acts were consciously employed by the teacher (the co-investigators of the study) throughout the lessons to make explicit for the children the connection between her speech and the action undertaken (Figure 1). By examining changes in the frequency of occurrence of these acts with reference to specific teaching goals in each lesson, it is possible to see "microgentic" changes in children's cognitive processing taking place.

[Insert Figure 1 about here]

Logo Discourse - Week One

All the Logo lessons followed a predictable sequence of phases: (1) transition, where the teacher discussed procedural items before beginning the actual teaching (e.g., setting up the disk, selecting the commands to be taught); (2) review, where commands taught the previous day were reviewed and practiced; (3) new learning, where the teacher introduced the new concept for the day and provided practice time; and, (4) closing, where the teacher summed up the session's work and rewarded children for their cooperative efforts.

To analyze instructional discourse, Sinclair & Coulthard (1975) developed the concept of exchange, which consists of an interaction orgranized into three parts: an initiation of some type, a reply, and a follow-up to the response. A number of exchanges tied together constituted a frame, which Bernstein (1975) noted refers to the degree of control teachers and pupils posses over the selection, organization, pacing and timing of the knowledge being transmitted. When lessons are

strongly framed, there is little variability in the discourse structure; when they are weakly framed, greater variability can be expected, and it becomes more difficult from the analyst's standpoint to mark the boundaries between frames.

According to Sinclair & Coulthard (1975), the teacher's primary functions can be categorized in terms of three types of exchanges: (1) Elicit exchange, one headed by an elicitation or question functioning to create a language response; (2) Direct exchange, one headed by an imperative functioning to request an action, a nonlanguage response; and (3) Inform exchange, one headed by utterances designed to be informative, to impart information to listeners. As an example of how the teacher dominates the discourse structure by initiating the exchanges, DeStefano, Pepinsky and Sanders (1982) found in their data from reading lessons that 100% of the direct and inform exchanges were initiated by the teacher, and almost all of the elicit exchanges (88%).

Using their data as a yardstick, the Logo lessons are somewhat different with respect to elicit and direct exchanges for both pairs of children (Table 1). Since neither of the children knew anything about Logo, it makes sense that the teacher would be the one providing all the information. However, it is clear that the children were asking far more questions than children usually do in other classrooms, although this figure is somewhat misleading in that most of the questions were generated by Andy, and tended to be off-topic (e.g., "Is there really a turtle in there?" as he pointed to the back of the computer).

[Insert Table 1 about here]

The important difference is that the teacher's questions were often of the type Mehan (1979) called metaprocessing elicitations, questions designed to get children to think about their actions. These questions were divided into three categories: (1) eliciting questions designed to get the children to recall previously learned material as a prelude to what the teacher wanted them to focus on next (e.g., "what is 'clear screen' supposed to do?"); (2) evaluative questions designed to get the children to think about what actions the "turtle" had just performed in relation to what they were trying to accomplish (e.g., "He just went off the screen. Is that what you wanted him to do?"); and, (3) planning questions designed to

get the children to think about their next set of actions in relation to what they had just done (e.g., "He's over here. How much further would you want him to go?").

Mehan (1979) reported that in his data such metaprocessing questions comprised only about 1% of the teacher's talk; in the first week of lessons, our data indicated that the teacher was using them about 8% of the time. Not a major difference, perhaps, but it does reflect the teacher's intent to get the children to think about what they want to do next. The low percentage is more a function of the teacher's need to get information across as to how to program the "turtle" and to direct children's actions concerning what to do next; at this stage, it was too early to expect children to think about what they were doing before they even knew how to do it.

If the differences in Logo discourse were limited to just these three types of exchanges, it would hardly mark a striking departure from other classroom discourse. But there were two other key differences, ones which raise the possibility that computer usage may establish new discourse patterns in the classroom, as well as a new role relationship between the teacher and students. These differences were analyzed by means of two new types of exchanges created for this analysis: (1) initiate exchange, one headed by an utterance proposing an action which the listeners may negotiate concerning its outcome; and, (2) co-direct exchange, one headed by an utterance which sets in motion a task jointly completed by a series of collaborative actions.

The decision to classify an exchange as an initiate exchange instead of a direct exchange (which it ostensibly resembled), depended upon the options the listeners had to refuse or contradict the proposed action, and to suggest an alternative action. In a direct exchange, the children had little option to refuse the teacher's directive, as illustrated in Example 1.

Example 1

(Mike has just finished typing in the command 'clear screen')

1-1 T: Now maybe Tina can press 'return'
1-2 Let's see what's gonna happen

1-3 (Tina presses 'return')

But in an initiate exchange, the teacher might propose an action which the children often refused to suggest their own action, or elaborated on the teacher's idea to make it their own. In Example 2, Mike adds onto the teacher's idea, which becomes part of the task:

Example 2

2-1 T: What about if we turn him [the 'turtle'] this way
2-2 And bring him back here and make a triangle

2-3 M: And then why don't we make him go upside down

2-4 T: Yeah
2-5 Why don't we turn him

In this case, the proposed action was jointly agreed upon; the teacher just didn't 'tell' Mike what to do. Example 3 illustrates how a child can gain momentary control of the discourse to work on her idea:

Example 3

(Karen and Andy have just finished practicing deleting letters)

3-1 T: Well boundary between frames
3-2 Let's try#

3-3 K: Now let's try the other one initiates her idea
3-4 this time backwards (picks up cardboard sheet with 'BK' command on it)

3-5 A: You just keep going like that (still practicing with delete key)

3-6 K: Cause if you keep on learning them
3-7 Wait till you come up here again
3-8 You'll learn how to do this (shows Andy 'BK' command)

3-9 T: And you can make the turtle move (points to screen)
3-10 And I'll show you some other turtle words today too

3-11 A: I can leave it off (pushes cursor key)

3-12 K: this time this time [reinitiates her idea]
3-13 Wait
3-14 Let me show#let me show you something (pushes Andy's hand away)

3-15 A: Let me do some (tries to put his hand back on the keys)

3-16 K: Wait wait wait (brushes his hand away)
3-17 I'm just going to show you how to do this

3-18 A: Don't touch these buttons

3-19 (Karen types in her command)

This short segment suggests the complexity of features in Logo discourse. Karen obviously wants to practice the 'BK' command, but Andy is still preoccupied with the previous task. She attempts to link his behavior to her idea; the teacher jumps in to forecast what else she plans to teach them that day. Failing to capture Andy's attention, Karen resorts to direct intervention, literally pushing him away from the computer. Initiate exchanges headed by a child were often of this type: children would propose their idea and bid for a turn; the teacher would only intervene if the children could not settle it themselves. Quite frequently what the children suggested would not work because it was the wrong format for a command (e.g., typing in their name before saving it as procedure); the teacher allowed them to proceed in order to use the mistakes as a teaching device. She then followed up on their behavior by using reflective meta-questions (or "metaprocessing elicitations") either to teach the appropriate command or to have the children figure out themselves what went wrong.

Behavior in the second type of category, co-direct, was even more complex. This exchange was really a meta-category, since within it were embedded behaviors similar in form to direct, elicit and inform exchanges. Watching the discourse unfold, however, it was clear that a co-direct exchange was much more than a series of sub-exchanges strung together. It was during these exchanges that the teacher began transferring control for regulating behavior over to the children. Even as early as the second lesson, the children were beginning to see the connections between the use of specific commands and the "turtle's" actions on the screen, as evident in Example 4:

Example 4

(Karen and Andy have just finished working on one design)

4-1 A: Let's do some more designs [Initiates action]

4-2 T: Well what else do you want to do?
4-3 Want it to turn (points to screen)
4-4 and go this way and make a line go
4-5 that way?

4-6 A: Yeah do that

4-7 T: Well let's see
4-8 You need to turn it up then
4-9 Let's see

4-10 T: You see (puts 'turtle' block up
4-11 on screen & turns it around)
4-12 The turtle's pointing this way
4-13 And we need it to go that way

4-14 K: So what we do...

4-15 T: So we want-
4-16 No let's put-
4-17 Well we might-

4-18 K: We need ah...RT (pulls out command)

4-19 T: Ok
4-20 Good
4-21 Good working Karen

4-22 K: 'RT' (addressed to Andy at the keyboard)

4-23 A: 'R' (looks for key)
4-24 Where's 'R'?

4-25 K: Both of them (holds his hand & guides it
to the 'R' key)

4-26 A: Don't tell me

4-27 T: You see what's happening
4-28 You'll need another line
4-29 How do we get another line before we
put that word in?

4-30 (Karen presses 'return')

4-31 T: There you go
4-32 Terrific

4-33 K: 'R'

4-34 A: 'R' 'T' (presses keys)

4-35 T: Nice helping

4-36 K: 'T'

4-37 (Andy moves to press 'return')

4-38 T: uh-huh (Andy pauses)
4-39 space (points to space bar)

4-40 K: space

4-41 T: How much do we need? (makes turning gesture on screen)
4-42 I think a good number might be five-o
4-43 Five and then zero

4-44 (Andy presses '5' and then Karen shows him '0')

4-45 T: This is a '0' over here (points to key)
4-46 Five zero
4-47 With the line
4-48 And then to make him do it you have to press...(points to return)

4-49 K: Return (presses key)

4-50 (The "turtle" turns right at a 50 degree angle)

Wertsch (1979) noted that at the first level of the transition from other-to self-regulation the issue is how the child begins to develop a definition of the task situation that will allow him/her to participate in the communicative context. In this segment we see that already by the second lesson both children (as well as the other pair) understood what was expected of them, and had moved on to the second level, which is characterized by the child's ability to interpret utterances in terms of the problem-solving situation (Wertsch, 1979). Even when the teacher's comments lack a clear referent as the next action which needs to be performed (lines 15-17), Karen is able

to make the necessary connection and finds the appropriate command. Although the teacher is still fairly explicit concerning actions needed to complete the command (lines 27-29 & 41-43), by using meta-hints (lines 42-43) and thinking aloud she is modeling the kinds of behavior the children will later be expected to perform for themselves.

The transfer of control implicit in both initiate and co-direct exchanges is indicated in the comparison between teacher-headed versus child-headed exchanges (Table 2). Because children are free to determine the next task to practice, and are encouraged to participate in making the "turtle" move, there is a greater equalization of control in the lesson. Out of the total number of exchanges for both pairs (N = 268), approximately 21% (N = 57) were of a collaborative nature. Since the goal of the study was to facilitate children's meta-cognitive processing through Logo instruction with mediated teaching strategies, we would expect that by the third week collaborative exchanges would increase, and the behavior within them would show children assuming an even greater strategic responsibility for completing the task. As the analysis for Week 3 indicates, both these expectations were met.

[Insert Table 2 about here]

Logo discourse - Week 3

By the ninth lesson in week 3, the children exhibited considerable prowess in manipulating the turtle's commands, and had even reached the stage of combining commands to create new procedures which they saved on disk. These procedures were then used to construct a design, the whole picture which was then saved. A comparison of direct versus collaborative teaching exchanges shows that while the teacher still controlled the discourse to a large extent, the percentages of collaborative exchanges headed by children increased over time, and overall, the number of collaborative exchanges increased to 30% of the lesson (Table 3). While the change from 21% to 30% is not a significant increase, it represents a trend toward the teacher's gradually shifting control from other-to self-regulation of behavior. Keep in mind that these are only five year- olds; how often do children this age have any influence over the discourse structure in terms of setting the task agenda in other situations? Rarely are young children given control over their own learning process, and it is a reasonable hypothesis to suggest that as children mature, greater equalization in

Logo instruction is likely to occur.

[Insert Table 3 about here]

Before moving on to a discussion of several issues which this study raises, it is worth taking a final look in example 5 at how children perform in a co-direct sequence where the teacher plays only a minimal role in directing the action, and instead monitors children's performance to provide reinforcing feedback.

Example 5

(Mike and Tina have been working on the goal of combining procedures to make a 'house' design)

5-1 T: Chim
5-2 Where is it? (picks up paper with 'chim' on it)
5-3 There it is

5-4 Ti: Mike I-

5-5 M: 'c' 'c' 'c' (presses 'c' key)

5-6 T: Here you go Tina (gives her the paper)
5-7 You can have that one

5-8 M: (still typing) 'c' 'h'
5-9 Ooh that's cool
5-10 'i' 'm'

5-11 T: Wow

5-12 M: now
5-13 'b' 'u' 'c' 'h'

5-14 Ti: now you're supposed to do 'b' 'u' 'c' 'h'

5-15 T: what's happening?

5-16 M: 'b' (presses key)

5-17 Ti: I know

5-18 M: 'u' (presses key)

5-19 T: nice working together you guys again

5-20 M: 'c'
5-21 'c' right there (points to key)

5-22 Ti: (presses 'c' key then 'h')

5-23 M: (presses return) now we have a home

In the exchange which followed this sequence, the teacher initated the next action by noting "now you can add something to the house actually," and the children began work on constructing a door. Their behavior is indicative of Wertsch's assertion that in the third level of the transition from other- to self-regulation, "the adult no longer has to specify all the steps which must be followed in order to interpret a directive since the child can carry these out on the basis of a fairly complete definition of situation...in some cases it seems that the child is functioning independently and that the adult is simply providing reassurances that what she/he is doing is correct" (1979, p. 15). Both pairs of children needed only minimal directives from the teacher to figure out what they wanted to do next.

Given the complexity of Logo programming, it is debatable whether these children ever functioned at the Wertsch's (1979) fourth level. At this level, "the child takes over complete responsibility for the problem-solving effort, and egocentric speech with its self-regulative function now appears during the shift to the intrapsychological plane" (Wertsch, 1979, p. 17). We did see some evidence of egocentric speech occurring, which we labeled self-cuing, but only with one child, Mike, who was the most cognitively advanced performer (based on a standardized verbal ability measure given before the study) of the four children. Again, we emphasize the importance of the teacher's behavior in modeling egocentric speech in thinking aloud to facilitate this transition, but it is likely the children were too young to take full advantage of it in regard to Logo programming.

Discussion

One question we can pose in regard to this analysis is: Why does Logo discourse appear so different in several respects from other kinds of classroom discourse? The answer lies in the teacher's goals in the lesson. Because these Logo lessons were part of what Popkewitz (1984) calls a teaching experiment, which involves the development of a teaching strategy to stimu-

late children's learning, the teacher was more fully cognizant of her behavior in realizing specific outcomes. In this case, the teacher was not teaching Logo in terms of what children should know; she was using it as a means of teaching children how to think. And this intent is consistent with Papert's ideas: Logo should free children to think for themselves.

Problems with Logo arose from Papert's mistaken asumption that children could develop self-regulative capacities independent of adult guidance; an assumption not unexpected when considering the fact that Logo was developed from Piagetian principles of cognitive development, which takes little account of the role of social interaction (Perret-Clermont, 1980). When researchers who studied Papert's ideas put them into practice with children learning Logo through the 'discovery method, not surprisingly they found that children failed to transfer any metacognitive skills learned to other situations (Pea & Kurland, 1984), and that even while using Logo they fell into a "hacking style of programming" which did not lead to learning the underlying principles inherent in the language (Leron, 1985; Zelman, 1985). Where there has been a moderately successful transfer of skills it has been through a careful structuring of the teaching process.

But as we stated in the beginning of this paper, we need to know more not only about the outcomes of Logo learning, but also about the process by which learning occurred. For this reason, the language of teaching is a critical component. We have used the discourse analysis of Logo instruction to suggest how the transfer from other-to self-regulation occurs in metacognitive thinking, and to point out features which set it apart from the usual classroom discourse. A notable feature is the fluidity of the discourse in terms of shifting topics (akin to Bernstein's concept of "weak frames"), where the topical agenda is often controlled by the children. More analyses of discourse within experiments would add to the growing body of literature on teaching as a linguistic process, as well as provide a means of assessing changes in behavior over time where other sources of variation have been controlled.

From a cognitive perspective, using the computer in this research allowed the teacher to make meaning more explicit to the children to make clear the connection between speech and thinking. Olson (1985) suggested this explicitness of meaning is an attribute of computer programming; the computer will only accept inputs which are clearly defined. Time after time the

teacher would point to the screen and say, "See what the turtle says? He says, 'I'm sorry I don't understand. I don't know that word.' That means you have to tell him a word he knows." This "talking to the turtle" made the children realize how absolutely specific they needed to be in inputting commands; the message was delivered in a way they couldn't ignore because without the proper commands the turtle just sat there. In one sense, the turtle's message was comparable to Wertsch's assertion that "adult directives to children which do not elicit the intended behaviors and must be followed by explicit directives which do elicit the appropriate behaviors are probably an important learning tool for the child going through the zone of proximal development" (1979, p. 21). We suggest the turtle functioned as a familiar object-to-think-with which children found very appealing and rarely became angry with for 'telling' them what went wrong.

The burden of recall was eased in two ways for the children: by having the commands left on the screen so the children could see and "debug" the problem without having to rely on memory; and by the teacher's verbalizations, which lessened demands on children's working memory to recall information. Case (1978) pointed out that young children are incapable of dealing with very many items of information at one time. By constantly thinking aloud, the teahcer was providing prompts to children's memory in recalling the appropriate commands, and also laying the groundwork for combining commands into procedures. In effect, the mediated teaching strategies were employed in a developmentally based theory of instruction advocated by Case (1978); the linguistic analysis demonstrated how such an approach is realized in 'real' life. Following this approach, young children are more competent in Logo programming that their age would predict.

A third issue is the ecological validity of this research. Because the Logo lessons occurred within a restricted context, we do not claim that the same results would be achieved in a regular classroom setting. But we would like to suggest two ideas for further research: (1) the theoretical framework upon which this research is based can be applied to other lessons besides Logo; for example, metacognitive prompting through self-questioning and modeling has been used successfully to improve children's comprehension monitoring strategies during reading (Meichenbaum & Asarnow, 1979; Miller, 1985; Palinscor & Brown, 1985); and, (2) it may well be that this discourse structure foreshadows a classroom where direct instruction to a large group is no longer the norm, and the teacher interacts

with students either one-on-one, or in small groups. In this model, peer collaboration will play a stronger role, and the teacher will become a knowledge-facilitator, not a knowledge-giver. As computers become less expensive and the software progressively more interactive, new discourse forms may evolve to describe the teaching-learning process.

One last issue merits attention, and given the changing demographics in public schools, it is one of no small concern. To date, much of the Logo research has been conducted primarily with both white, middle-class children of average and above-average verbal cognitive ability. Even Wertsch (1979) noted his conclusions were limited to a white, middle-class population. But we have used mediated teaching strategies with minority/white children from low-income backgrounds whose abilities based on standardized tests would lead people to believe they are not ready for sophisticated programming. In this study, our five year olds achieved much more than expected, and in a forthcoming paper, we report on first grade low achievers who progress far beyond their predicted capabilities. These are the children who need the most assistance in crossing the zone of proximal development. Unfortunately, these same children are often the ones most likely to be relegated to endless drill and practice of basic skills. While we agree basic skills should not be neglected, it is precisely the "learning how to learn" skills promoted through mediated programming experiences that are needed by these students. Knowing how to use language in the form of private speech to guide one's own thinking is a skill that 'brighter' children appear to acquire effortlessly. Gumperz and Cook-Gumperz (1984) coined the phrase. "communicative resources as cultural capital;" this apt phrase captures the idea that success in life depends upon using language successfully in multiple contexts. Children labeled as deficient in ability by their performance on standardized tests are in reality as capable as 'brighter' children in Logo programming; what they lack are the appropriate mediated strategies by which metacognitve skills are acquired. By giving children a greater range of language capabilities through the teacher's modeling of metacognitive strategies, we provide them with the capital to spend on their own learning. The technological future looming over the horizon requires that children will not need to learn to know, but to know how to learn. By studying discourse in a multitude of teaching contexts, we hope to build a framework by which this goal can be accomplished.

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Figure 1

Cognitive Teaching Acts for Logo Training

Name of Act	Description	Examples
Meta elicit (Mel)	Agent asks receiver to recall information previously learned	-Remember what those were for? -What is ___ supposed to do? -How do we get a new line?
Meta evaluation (Mev)	Agent asks receiver to evaluate ongoing actions	-What happened? -What did the turtle just do? -What's going to happen when we put _____? -Do you know why that's there? -How far did he go? -Did the turtle do what you told him? -Did you want him to go that way? -Do you know what I am doing?
Meta prompt (Mp)	Agent is asking receiver to think about or reflect on what they want to do next.	-What do you want the turtle to next? -Which way do you want him to point? -How will you make him go there? -What else do you want him to do?
Planing prompt (pp)	Agent indicates there is a next action planned but it has not been in response to reflective thinking.	-Let's try the other one. -Let's make him go forward and put a line up here.
Direct intervention (Di) or Direct (D)	Agent explains and demonstrates what to do to the receiver Agent explains or tells what to do the receiver	-Let me show you something. -And now put 'd' -Put space and then 70. -Tell Kia what she should do.
Self-cuing (Sc)	Agent verbalizes some meta and other direct statements to guide their actions.	-OK, What am I going to do? -Hmmm, I will have to put in a BK. -I think I know what happened? -How will I make hime get there? -Did that turtle do what I told him?
Task evaluation (Ev)	Agent reinforces or praises actions which complete a task	- That's terrific. You made the turtle go up there - Very good. You made a house

Table I

Types of Teaching Exchanges[a] - Week One

	Teacher-headed[b]		Child-headed[c]		Total	
Exchange type	N	%	N	%	N	%
1. Elicit	49	23	39	19	88	42
2. Direct	57	27	7	3	64	30
3. Inform	59	28	-	-	59	28
	165	78	46	22	211	100

[a]Excluded are such exchanges as Check, Listing, Repeat

[b]The teacher begins the exchange

[c]The child begins the exchanges

Table 2

Types of Collaborative Exchanges - Week One

	Teacher-headed		Child-headed		Total	
Exchange type	N	%	N	%	N	%
1. Initiate	15	26	22	39	37	65
2. Co-direct	12	21	8	14	20	35
	27	47	30	53	57	100

Table 3

Comparison of Teaching and Collaborative Exchanges - Week Three

	Teacher-headed		Child-headed		Total	
Exchange Type	N	%	N	%	N	%
1. Elicit	54	24	17	7	71	31
2. Direct	38	17	5	2	43	19
3. Inform	21	9	25	11	46	20
4. Initiate	11	5	23	10	34	14
5. Co-direct	10	4	26	11	36	16
	134	59	96	41	230	100

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